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INFRARED DIRECTION FINDERS

SUMMARY (Give summary which highlights the salient factors of narrative report. Begin narrative text on AF Form 112a unless report can be fully stated on AF Form 112. List inclosures, including number of copies)

I. SUMMARY: This is a summary of the article "Teplopelengatsiya - sredstvo razvedki" (Heat direction finding - means of reconnaissance), by E. Kosyrev, Engineer Major, in: Voyennyye znaniya (Military science), no. 10, 1959, p. 19-20, which describes the principle of operation and various applications of infrared receivers and tracking devices in military practice.

II. DISTRIBUTION: Normal

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1 INCLS

1. Fig. 1 - Receivers of infrared energy (sketch)
2. Fig. 2 - Antiaircraft infrared direction finder (sketch)

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INFRARED DIRECTION FINDERS

General Consideration.

New possibilities of application of electromagnetic radiation for reconnaissance purposes have been developed recently. This achievement was due in large measure to the study and application of infrared techniques.

Depending on the methods of their employment, radar as well as infrared devices can be divided into active and passive systems.

An active system requires the illumination by a beam of infrared energy emitted by an infrared projector. A part of the energy is reflected from the object and comes back to a special receiving device located at the point of observation. By this means it is not only possible to detect the target but also to fix its position within the field of vision.

The passive system of observation is based only on the detection of their own energy emitted by objects above absolute zero (-273°C) in the form of infrared rays (thermal radiation of the heated surfaces).

The night vision equipment presently used for reconnaissance purposes belong to the active means. A powerful infrared projector lamp is its inseparable element. However, the use of the lamp reveals the projector position even at great distances.

The advantages of passive infrared detection devices referred to also as the infrared direction finders are indisputable. They operate without illuminating the terrain or the object of observation, they are simple in operation and servicing and their dimensions and weight are reduced to a minimum. The basic advantage of their use is complete secrecy of action. The efficiency of operation depends here on the intensity of the infrared energy specifically to separate radiating objects.

Two basic properties of infrared radiation have drawn the attention of military experts; first, they are invisible to human eyes, secondly, all objects located on the battlefield can be practically considered as the sources of infrared radiation. Both factors are of great importance when the secrecy of military operations is considered.

The Infrared Energy Detectors.

While encountering some bodies, the radiant energy is absorbed by them and transferred into thermal, electric and chemical energies. This phenomenon was used in isolating various types of infrared energy detectors such as thermocouples, bolometers, pneumatic cells (indicators) and photoresistors (See Fig. 1 at the end of this summary).

In the event radiant energy heats the junction of two different metals and produces thermo-electromotive force of such extremely low magnitude that special preamplifiers are required to make measurement of the signal possible.

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The bolometer is the most widely used type of infrared detector. It represents a thin semiconductor of black painted flakes (to increase absorption of radiant energy) which, when exposed to infrared radiation heats up and its resistance decreases. Usually the bolometer is cut into a measuring bridge with A.C. supply 300-500 KC. The thermocouples and bolometers are very sensitive, but their disadvantage lies in considerable inertia which makes it difficult to detect targets moving at high speed.

The pneumatic detector of infrared radiation also belongs to the group of thermal devices. It consists of a metallic body with an air filled camera (gases) closed at both ends with film diaphragms; one of these thin films which serves to absorb the heat exposed to infrared radiation; another made of much thinner film, deforms under pressure of the expanded heated air and serves as an indicator of the presence of radiation in the observer's field of vision. The pneumatic detector is characterized by high sensitivity and small dimensions (3mm high and 3mm diameter).

Photoresistors or photoconductive cells are made from semiconductor materials which, while exposed to infrared radiation, increases the number of free electrons thus increasing its conductivity. The detector circuit consists of the photoresistor, load resistor, and power supply. The variation of current flow in the photoresistor results in voltage drop across the load resistor. These varying voltages are amplifying and are applied to the indicator which records the variation of infrared radiation.

Infrared Direction Finder.

The finder consists of two basic units; optical system with infrared receiver and target position coordinator (See Fig. 2).

The optical system is supposed to collect as much as possible of the radiant energy emitted by the target and transfer it to the receiver by means of a parabolic mirror reflector. Flux of infrared radiation is focussed by the mirror upon the surface of the detector. The mirror is placed in a light metallic drum which protects it from the side reflections and mechanical damage. Selection of the type of receiver-detector, as well as radiation patterns of the probable targets play a decisive role in the design of the direction finder. An amplifier located at the output of the receiver plays a very essential role in the whole system. Either D.C. or A.C. amplifiers are used here. The application of semiconductor devices (transistors) considerably simplifies the design of the amplifiers.

Target position coordination (coordinate scale) serves to determine the target position in relation to the optical axis of the direction finder. This data can be used for automatic and continuous tracking of the target within the direction finder range.

The major component elements of the coordinator are the modulator and disk commutator (optical chopper). The purpose of the modulator is to chop the radiant flux incident to photoresistor, thus the A.F. amplifier can be used for signal amplification. Modulation of radiant flux is performed by means of a disk modulator driven by a special electric motor. Immediately behind the modulator there is a disk commutator provided with a radial slot. The detector (photoresistor) senses the target radiation and in its circuit signals appear in the form of pulses alternating with modulation frequency 800 c/s. After passing through A.C. amplifier, the signals are applied to the indicator device, which

jointly with the disk-commutator makes it possible to determine the target position in relation to the finder axis. In the indicator device there is a small neon bulb which revolves in step with the disk commutator. The bulb is supplied from the photoresistor amplifier.

If the target is on the edge of the direction finder's field of vision and the radiation passes through the edge of the disk-commutator, then its slot transmits the radiation toward the thermoresistor only within a very limited angle of revolution. The remaining part of the disk overlaps the radiant flux. After amplifying, the received signal lights the neon bulb only within that limited angle. With the approach of the target to the optical axis of the direction finder, the duration of the bulb's glow increases. When the target reaches the axis, the glowing remains uninterrupted. This occurs due to the fact that during the revolution the linear speed of the disk slot in relation to the target image varies, depending upon its distance to the disk center.

Using the hand wheels of the tracking mechanism, the operator attempts to keep the neon bulb glowing uninterruptedly, i.e., it must be centered on the target along the optical axis of the direction finder.

The accuracy achieved by that method is close to one tenth of a degree at a range of 20 km.

Application of Infrared Direction Finding Equipment.

Detection of slightly heated targets is possible due to the use of highly sensitive receivers of radiant energy. According to information gathered by the author, today's aircraft infrared direction finders provided with ultrasensitive bolometers make it possible to detect from air submarines submerged up to 40 meters due to the temperature difference existing between the wake and ambient water which varies within 0.05 and 0.5°C.

Aircraft thermal gunsights and direction finders are used extensively in the air force. Such a sight installed in the nose of an all weather interceptor detects the enemy aircraft for a range of 8-10 km. at average heights.

Recently, the principle of thermal direction finder have been extensively used in the design of heat seeker heads of infrared guided missiles. Possessing comparatively small dimensions and weight and consuming low energy they operate effectively for ranges of some few kilometers on the ground and few tenths of kilometers on the sea and in the air. The resolution of these infrared devices is very high as compared with 8 mm. wavelengths radar equipment working at the same range.

The essential disadvantage of the infrared direction finding system is its range dependence on atmospheric conditions, time, amount of radiation energy emitted by the target and the difficulty of measuring the distance to the target. The best results have been obtained under night conditions and at high altitudes when the amount of foreign impurities in the air is very low.

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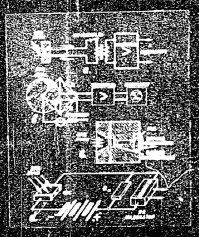

Fig. 1 - Receivers of infrared energy: a - thermocouple; b - bolometer; c - pneumatic indicator; d - photoresistor.

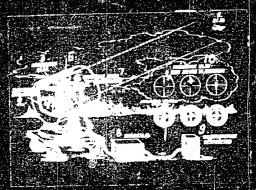

Fig. 2 - Antiaircraft infrared direction finder.

Legend: 1 - target; 2 - mirror reflector; 3 - target coordinator; 4 - motor; 5 - modulator; 6 - disk-commutator; 7 - infrared receiver (photoresistor); 8 - amplifier; 9 - indicator; 10 - target position in the direction of finder's field of view vision.